U.S. Army Research, Development and Engineering Command

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Development of Environmentally Friendly Insensitive Pyrotechnic Munitions with Enhanced Battlefield Performance

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14. ABSTRACT

Over the past decade, Armament Research, Development and Engineering Center (ARDEC) has been involved in many environmental remediation programs in an effort to address the pressing environmental concerns of many pyrotechnic munitions in the U.S. Army?s arsenal. Recent development of environmentally benign variants of the M115A2 ground burst projectile simulator, the M116A1 hand grenade simulator, the M117, M118, and M119 booby trap simulators, the M274 2.75? rocket smoke charge, and the battlefield effects simulator are noteworthy examples of previous success stories. The most recent success stories, such as the development of environmentally conscious red green and white light-emitting pyrotechnic illuminants will be discussed in detail. Specifically discussed will be the use of high-nitrogen compounds as a potassium perchlorate replacement toward the successful prototype development of M126A1 red star and M195 green star illuminants, the development of a barium-free variant of the M159 white star illuminant, and development of barium-, perchlorate- and chlorine-free green illuminants. The use of boron carbide toward the development of barium-, perchlorate- and chlorine-free green light emission will be discussed in significant detail due to its novel usage, and far-reaching potential in military and civilian pyrotechnic applications. The comparable/reduced sensitivities of the developed illuminants to various ignition stimuli, and their enhanced battlefield performances compared to the environmentally questionable formulations are also of significant importance. Ongoing pyrotechnic environmental remediation programs at ARDEC to be mentioned include areas pertaining to anthraquinone-free yellow smoke munitions for signaling purposes perchlorate- and barium-free IM-28 incendiary compositions, and the development of perchlorate- and barium chromate-free pyrotechnic delay fuzes for multi-purpose applications.

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DEVELOPMENT OF ENVIRONMENTALLY FRIENDLY INSENSITIVE PYROTECHNIC MUNITIONS WITH ENHANCED BATTLEFIELD PERFORMANCE

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Over the past decade, Armament Research, Development and Engineering Center (ARDEC) has been involved in many environmental remediation programs in an effort to address the pressing environmental concerns of many pyrotechnic munitions in the U.S. Army's arsenal. Recent development of environmentally benign variants of the M115A2 ground burst projectile simulator, the M116A1 hand grenade simulator, the M117, M118, and M119 booby trap simulators, the M274 2.75" rocket smoke charge, and the battlefield effects simulator are noteworthy examples of previous success stories.

The most recent success stories, such as the development of environmentally conscious red, green and white light-emitting pyrotechnic illuminants will be discussed in detail. Specifically discussed will be the use of high-nitrogen compounds as a potassium perchlorate replacement toward the successful prototype development of M126A1 red star and M195 green star illuminants, the development of a barium-free variant of the M159 white star illuminant, and development of barium-, perchlorate- and chlorine-free green illuminants. The use of boron carbide toward the development of barium-, perchlorate- and chlorine-free green light emission will be discussed in significant detail due to its novel usage, and far-reaching potential in military and civilian pyrotechnic applications. The comparable/reduced sensitivities of the developed illuminants to various ignition stimuli, and their enhanced battlefield performances compared to the environmentally questionable formulations are also of significant importance.

Ongoing pyrotechnic environmental remediation programs at ARDEC to be mentioned include areas pertaining to anthraquinone-free yellow smoke munitions for signaling purposes, perchlorate- and barium-free IM-28 incendiary compositions, and the development of perchlorate- and barium chromate-free pyrotechnic delay fuzes for multi-purpose applications.

Overview

US ARMY RDECOM

- Past success stories within ARDEC's Pyrotechnics Technology & Prototyping Division

- Environmentally Friendly Battlefield Illumination Development
  - -High-nitrogen technologies for battlefield illumination
  - -Barium- and chlorine-free green light-emission
  - -Barium-free white light-emission

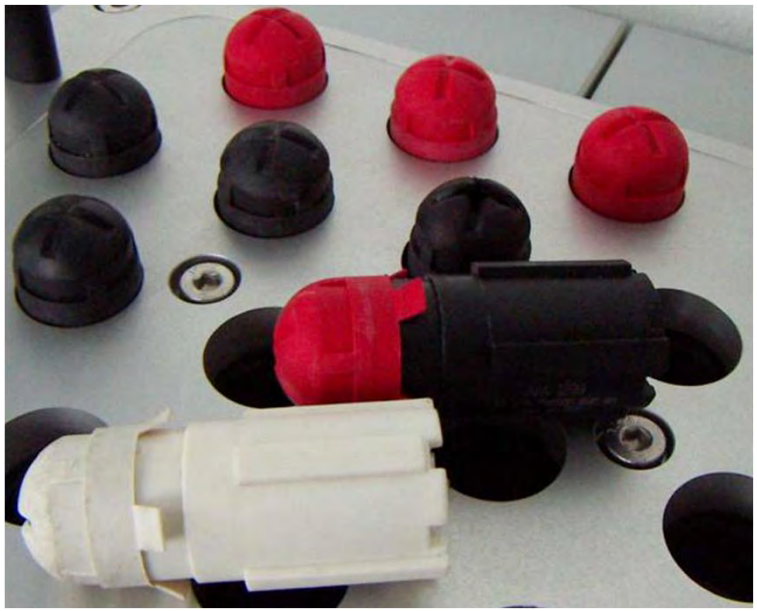
- Sensitivities of successful battlefield illuminants

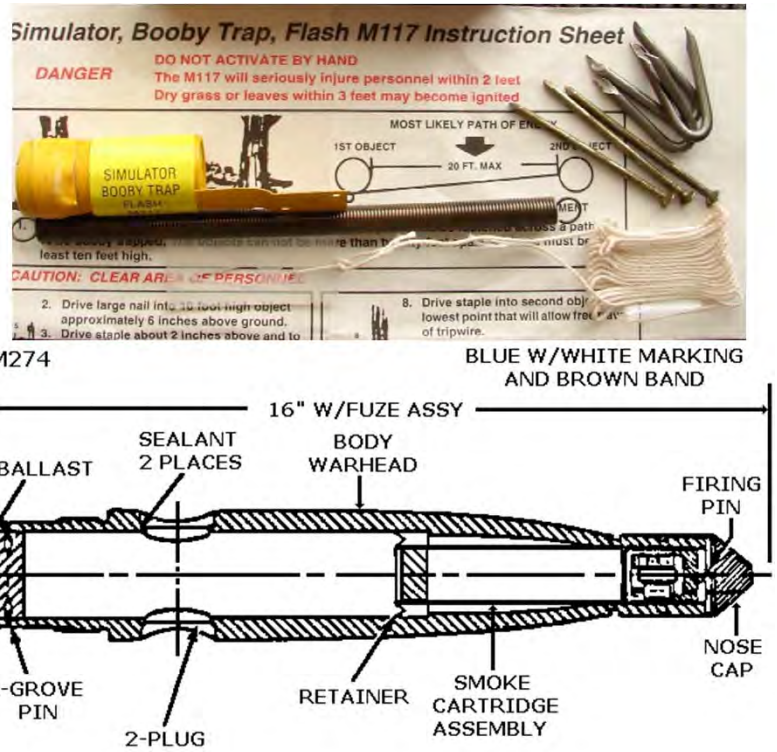
- Other ongoing environmental initiatives within ARDEC Pyro
  - -0.50 caliber armor-piercing incendiary
  - -Yellow smoke hand-held signaling
  - -WP and HC smoke replacement
  - -Pyrotechnic delay fuze development

Past Success Stories

US ARMY RDECOM

- M115A2 ground burst projectile simulator
- M116A1 hand grenade simulator
- M117 (flash bang), M118 (illum), and M119 whistling booby trap simulators
- M274 2.75” training rocket smoke charge
- Battlefield effects simulator





Visible Light Illuminants

- Hand-held signals (6), 40mm illuminants (5), 60/81/120mm mortars, 105/155mm artillery, 2.75” rocket.
- Can hand-held signal munitions be developed that burn longer and/or brighter?
  - -Longer burning munitions can reduce bulk load of the item upon redesign
  - -Brighter burning munitions have both military and civilian importance

KP-Free Formulations

M126A1 Control	
Component	Wt %
$Sr(NO_3)_2$	39.3
Mg 30/50	14.7
Mg 50/100	14.7
PVC	14.7
$KClO_4$	9.8
Laminac 4116/Lupersol	6.8

Formulation **A**	
Component	Wt %
$Sr(NO_3)_2$	39.3
Mg 30/50	29.4
PVC	14.7
$Sr(MNT)_2$	9.8
Epon 813/Versamid 140	6.8

Formulation **B**	
Component	Wt %
$Sr(NO_3)_2$	39.3
Mg 30/50	35.4
PVC	14.7
$Sr(MNT)_2$	3.8
Epon 813/Versamid 140	6.8

Identification	Burn Time (sec)	Luminous Intensity (cd)	Dominant Wavelength (nm)	Spectral Purity (%)
M126A1 Control	54.0	15,194.9	613.1	88.6
Formulation **A**	63.3	16,285.0	612.5	89.9
Formulation **B**	55.1	24,490.1	612.7	91.6

KP-Free Formulations

Formulation	Impact [J]	Friction [N]	ESD [J]	Thermal Onset [^{o}C]
M126A1 Control	8.8	80	>0.25	264.6
A	10.8	160	>0.25	235.1
B	10.8	>360	>0.25	231.2

KP-Free Formulations

M195 Control	
Component	Wt %
$Ba(NO_3)_2$	48
Mg 30/50	22
Dechlorane Plus (DP)	15
$KClO_4$	10
Laminac 4116/Lupersol	5

Identification	Burn Time (sec)	Luminous Intensity (cd)	Dominant Wavelength (nm)	Spectral Purity (%)
M195 control	55.0	5,832.0	562.3	65.3
Formulation **C**	59.3	6,608.7	564.6	69.4
Formulation **D**	58.1	6,104.6	563.2	69.9

- Formulations do not contain DP

KP-Free Formulations

Formulation	Impact [J]	Friction [N]	ESD [J]	Thermal Onset [^{o}C]
M195 Control	6.9	120	>0.25	622.0
C	11.8	>360	>0.25	583.6
D	8.8	>360	>0.25	559.0

Barium-Free Illuminants

M159 Control

Components	Wt %
Barium Nitrate	49.5
Magnesium 30/50	29.5
Strontium Nitrate	16.5
Laminac 4116/Lupersol	5

Formulation **E**

Component	Wt %
Mg 30/50	29.5
$NaNO_3$	65.5
Epon 813/Versamid 140	5

Formulation	Burn Time (sec)	Luminous Intensity (Cd)	Dominant Wavelength (nm)	Spectral Purity (%)
Mil-Spec	6.5 min.	25,000 min.	575±10	50 max.
M159 control[a]	7.6	26,160.0	584.2	49.6
E[b]	13.1	38,872.5	588.5	87.6

a] 21.4 g consolidated in 1 increment at 2,450 kg.

b] 21.4 g consolidated in 3 increments at 6,818 kg.

Barium-Free Illuminants

US ARMY RDECOM

Formulation **F**	
Component	Wt %
Mg 30/50	34.5
$NaNO_3$	60.5
Epon 813/Versamid 140	5

Formulation **G**	
Component	Wt %
Mg 30/50	39.5
$NaNO_3$	55.5
Epon 813/Versamid 140	5

Formulation **H**	
Component	Wt %
Mg 30/50	44.5
$NaNO_3$	50.5
Epon 813/Versamid 140	5

Formulation	Burn Time (sec)	Luminous Intensity (Cd)	Dominant Wavelength (nm)	Spectral Purity (%)
M159 control	7.6	26,160.0	584.2	49.6
F	10.9	50,622.7	588.7	88.4
G	9.1	68,805.8	588.1	85.7
H	8.5	76,731.2	588.2	86.7

Barium-Free Illuminants

Formulation	Impact [J]	Friction [N]	ESD [J]	Thermal Onset [°C]
M159 Control	11.8	240	>0.25	287.6
H	11.1	>360	>0.25	265.8

M159 Control

Formulation **H**

Boron Carbide Illuminants

US ARMY RDECOM

M125A1 Control	
Components	Weight %
Barium Nitrate	46
Magnesium 30/50	33
Polyvinyl Chloride	16
Laminac 4116/Lupersol	5

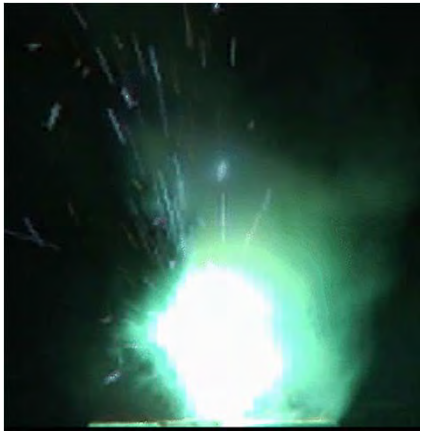
Formulations **I** and **J**.	
Components	Weight %
Potassium Nitrate	83
Amorphous Boron or Boron Carbide	10
Epon 828/Epikure 3140	7

Formulation	Burn Time (sec)	Luminous Intensity (cd)	Dominant Wavelength (nm)	Spectral Purity (%)
M125A1 Control	8.2	1,357.4	562.3	61.5
I	2.3	1,706.5	563.7	55.0
J	9.7	1,403.3	561.9	52.0

Boron Carbide Illuminants

US ARMY RDECOM

Formulation	Impact [J]	Friction [N]	ESD [J]	Thermal Onset [°C]
J	>63.7	>360	>9.4	403.5



M125A1 Control

Formulation **J**

Formulation **K**

Other Ongoing Programs

US ARMY RDECOM

- Yellow Smoke Signaling
- 0.50 Caliber Armor Piercing Incendiary
- WP and HC Replacement
- Environmentally Friendly Delay Fuzes

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